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ABSTRACT

Students pursuing master's and doctoral degrees in disciplines other than statistics are required to take applied courses in descriptive and inferential statistics. These students are the brightest in their disciplines but lack mathematical background. Most are older, mature, working professionals who want the best out of these courses. Yet, they do not have more than six credit hours to spare for statistics. These nontraditional students may occupy important career positions after graduation and are likely to use statistics to make advances in their own professions. Although this group of students is the best resource available to promote statistics and its applications across other disciplines, educators are least concerned about their needs. Teaching these students is a great challenge that demands the best of the instructor. The issues and concerns that face educators in teaching nontraditional students are raised. Some of the challenges discussed include assessing students' needs, lowering their anxiety, selection of appropriate teaching strategy, content delivery, integration of technology with instruction, and finding examples to which students can relate. (Contains 2 references.) (Author/SLD)

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Teaching Statistics To The Brightest of Other Disciplines

Abstract

Students pursuing master and doctoral degrees in disciplines other than statistics are required to take applied courses in descriptive and inferential statistics. These students are the brightest in their disciplines but lack mathematical background. Most are older, mature, working professionals and want the best out of these courses. Yet, they do not have more than 6 credit hours to spare for statistics. These non-traditional students occupy important career positions after graduation and are likely to use statistics to make advances in their own professions. Although this group of students is the best resource available to promote statistics and its applications across other disciplines yet, educators are least concerned about their needs. Teaching these students is a great challenge and demands the best out of the instructor. The issues and concerns that face educators in teaching non-traditional students have been raised in this paper. Some of the challenges that are discussed include assessing students' needs, lowering their anxiety, selection of appropriate teaching strategy, content delivery, integration of technology with instruction, and finding examples that students can relate to.

Teaching Statistics To The Brightest of Other Disciplines

Doctoral programs in all disciplines require their students to take courses in statistics and research methodology to read and understand the existing body of research literature as well as to develop skills to conduct research. Special courses in statistics are offered to meet the needs of these students. In addition to descriptive and inferential statistics, courses are offered in experimental design, nonparametric statistics, and multivariate techniques. Most of the students pursue a six-credit-hour sequence in which the first course introduces basic statistical concepts, normal distribution, testing hypotheses, t-test, analysis of variance, chi-square, correlation, and bivariate regression. The second course focus on the methodology and introduces most commonly used experimental designs, and techniques to conduct descriptive, correlational, and ex-post-facto research. Although students enrolled in these courses are the brightest in their disciplines, a large number of them cannot perform to the best of their abilities. Some of them are so scared that they keep postponing these courses for semesters. This is particularly true for the first course of six-credit-hour sequence. Even those who have done reasonably well acknowledge that the experience was not that pleasant and are relieved that the course is over.

Several measures are in place to provide positive experiences to students taking these courses. A strong advisory system exists

at almost every campus to assist students in the selection of courses that best suit their needs. Pre-requisite courses are also made available for those who lack adequate background. Efforts are also made to conduct the courses in the most applied fashion with no derivations and without the use of calculus. However, it appears that these measures are not adequate and something more needs to be done. The rest of the paper is focussed on the identification of factors that possibly hinder students' achievement and offers some suggestions.

Since the ability of students is not an issue here as they all are the highly select group, it is important that we carefully examine other factors that may hinder students' learning. Such factors include the selection of content, delivery of content, students' learning style, attention style, difficulties encountered by students in these classes, and the problems faced by the instructor.

Selection of Content

When it comes to teaching statistics to students in non-statistic majors, the task of defining content becomes a challenge. Several factors influence this decision. As a statistician, one considers everything statistical worthwhile to study and is tempted to include it in the syllabus. The difficulty arises when the selected content far exceeds the number of courses these students can take. The diverse background of students and their different levels of mathematical preparation make the selection of content

even more difficult. Since students in these courses neither intend to become statisticians nor are likely to make significant contribution in the field of statistics, the statistical procedures that are currently in use or are likely to be used in their professions should be included for study.

Content Delivery

The delivery of content plays a significant role in making applied courses in statistics successful and in providing positive experiences to students. The list of topics to be covered in these courses is generally long for a sixteen week term. In addition, inadequate mathematical preparation of students makes it difficult to move at a faster pace. Therefore, a strategy is needed to accomplish the goal of completing the course content in a given time frame with minimal loss of students. Such strategy can be developed by examining the course objectives. It generally involves (a) teaching statistical concepts in non-mathematical format, (b) emphasizing applications and skipping the theoretical treatment, and (c) encouraging computer usage over hand computations. Although this strategy would produce students who are skilled in the selection and execution of statistical procedures and can read and interpret computer printouts, many educators believe that the compromises made are too many and would adversely affect the quality of the program.

The colleagues who believe that teaching statistics without adequate theory as well as teaching statistics to students who have

little mathematical preparation is a joke, must view their argument in terms of students' motivation to learn statistics. The criticism implies that students are excited to learn statistics and are going to be fascinated when exposed to wonderful concepts of experimental design and testing of hypotheses. On the contrary, the majority of students who enroll in these courses are unwilling participants in the learning process. They are forced by program requirements to take these courses and many times keep postponing their enrollment for semesters. Many of these students see no place for statistics in their career goals and consider statistics courses a waste of their time. Obviously, there is a clear distinction in the motivation of students who want to get a degree in statistics and those who want to use statistics in their disciplines. The instructors teaching these students spend most of the time fighting students' resistance to appreciate and learn statistics. In spite of teacher's efforts to present material in a fashion that will relate to a variety of disciplines students represent and to make it comprehendible by all irrespective of their mathematical background, the instructor receives poor student ratings. These are, in fact, some of the reasons that discourage most of the faculty to teach these courses.

The concern that teaching statistics in pure applied fashion with total disregard to the underlying theory may produce students who are not trained to handle complex analyses and may apply incorrect procedures and misinterpret results, seems unfounded. Since students in the applied courses are primarily consumers of

statistics and would rarely be engaged in testing or developing statistical theories, it makes sense to keep theoretical treatment of the topics to the minimum. The theory should be introduced to the extent that it satisfies the curious minds and to make them believe that the procedures under discussion would, in fact, work. Heavy emphasis on the applications will make students appreciate the contribution of statistics in their disciplines and in achieving career goals. In the process, they will come to the realization that they do not know all about statistics and the knowledge acquired in applied courses is limited to certain applications. This awareness create the need to consult a trained statistician whenever a complex situation arises. Some of the students are intrigued and fascinated by statistics and end up taking several advanced courses. This group of students form a new breed of professionals who not only know statistics but have working knowledge of at least one other discipline -- a characteristic lacking in pure statistician.

The levels of mathematical preparation that are represented in a single classroom of an applied statistics course, alone, suggests that the technique of delivering the content in these courses should be modified to maximize learning. The very assumption that all students have a minimum of mathematical background is seldom true. Many times, students have taken the preparatory courses several years ago and have forgotten the material completely. Even the recently completed preparatory courses do not guarantee that the student has retained the material. This is particularly true

when the material learned has never been used. If these students are taught the same way as students who have chosen statistics as their profession, their anxiety level will reach a point that learning will not take place.

Teacher's sensitivity to relate the material to students' disciplines is also crucial to make them interested in statistics. It is not difficult to imagine the frustration of a business student who is being taught statistics using examples from agriculture. The inability to link statistical abstractions with the existing knowledge cause severe anxiety among students. All of a sudden, these accomplished adult professionals start feeling that they are dumb and cannot grasp basic concepts. They become ashamed of themselves and hurt their self esteem. Soon, they realize that they are about to fail the course. Because of shame, humiliation, low self esteem, and high anxiety, they stop making any effort to improve their standing in the class. Instead, they wait quietly for the inevitable to happen. Although these feelings are created unintentionally, they are real and have devastating effect on students.

Learning Style

Learning theorists believe that classroom instruction is effective only when the mode of presentation matches with the learning style of the student. Every individual is believed to have a unique style as well as the flexibility to adjust the style to accomodate a situation that demands a different style. However,

the adjustment cannot be large enough to categorize the person in a different category. A large body of literature is available on learning style (Keef, 1987) and recommends presentation strategies for instructors to accommodate students with different learning styles. Use of such strategies can also help students in learning statistics.

Attention Style

Nideffer (1978) felt that the attention style of an individual plays a critical role in determining the accuracy of response exhibited by the respondent. If the signals from outside environments are accurately received and processed, the likelihood of correct response increases. He theorized four types of attention: internal active, internal passive, external active, and external passive. Nideffer believed that all individuals have the ability to move from one style to another as the stimulus warrants but every individual has one dominating style. The implications of this theory are tremendous particularly in the context of teaching statistics. It is possible that students whose areas of study are more concrete and verbose than abstract and quantitative have developed an attention style that best suits them in courses of their studies but put them at risk in the statistics course. Although individuals have the ability to change the attention style, some learn it faster than the others. If this theory holds true, the attention style of students can be adjusted through training to maximize achievement in statistics.

What will we lose?

It is very easy to blame students for their failures and for the mental anguish they go through in the statistics course. After all, it is their decision to get into the statistics course knowing that they did not have adequate preparation to successfully complete it. Professionally, it would be unethical not to share the responsibility particularly when the outcome could have been reversed. We all know the contribution of statistics in other disciplines as well as the role it can play in the future. As statisticians, it is our responsibility to promote the use of statistics for the betterment of the society. The best way to accomplish this goal is to train students who are likely to assume leadership positions in other disciplines. By blaming students and professionals of other disciplines for their failures, we, in fact, discourage them to learn and use statistics. In doing so, we slow the process of research and development and deprive the society of future research benefits. It is, therefore, important that we assume our responsibility to serve the needs of students enrolled in applied courses. Otherwise, we will fail miserably in promoting statistics.

What do we want to teach?

The most important goal of teaching statistics to non-statistics majors is to make them appreciate statistics by showing how various statistical techniques can help them in their professions. This can be accomplished easily by knowing students'

background and bringing examples to the class that fit to their professions. Once they understand the usefulness of statistics, they become eager to learn techniques which can help them make significant contributions to their disciplines. These students have absolutely no idea about the importance of statistics when they first walk into the statistics class. They firmly believe that statistics has nothing to do with their career plans. They cannot imagine how statistics can improve their productivity and, at the same time, open up more avenues for their career growth. It is, therefore, important that we successfully communicate to these students that learning statistics is, in fact, an integral component of their program of study and is not something that the graduate school has imposed on them.

Because of increased use of technology in the work place, it is important that students learn about computers and the statistical software available in the market. Computer data analysis should also be encouraged over hand computations for quality control reasons. Good statistical software is thoroughly tested before marketing and the probability of making computational error is minimal. Most of the software have built-in feature to detect logical errors. Once the accuracy of computations is ensured, the task left is to correctly interpret the computer printout. It is therefore, very important that our courses should include a meaningful and significant effort to provide this skill to students.

The selection of statistical software for instructional

purposes is not very difficult. However, you need to decide whether you would require your students to buy the software or you would provide them access through the mainframe or a computer lab. The experience indicates that students who own the software and install it in their home computers are more likely to use it and that such use continues after completion of the course. If the choice is the personal ownership of the software, select the one that can do a reasonable job and is still affordable by students. Several vendors offer student versions of prestigious software such as SAS, SPSS, BMDP, NCSS, and MINITAB at affordable rates. These student versions are sufficient to meet classroom needs. In addition, they are menu driven and are easy to learn. The use of a less known software in class will not affect students' ability to later learn a more popular software.

When students are not required to buy software, the instructor should provide students access to computer labs. Because of low prices for personal computers, labs can be established at a modest budget. The cost of software can easily be controlled by Local Area Networking or by leasing the mainframe version of software for multiple user access. Computer labs equipped with LAN's offer the most cost effective means to provide instruction.

Challenges for teachers

Students in the graduate level introductory statistics class come from diverse academic backgrounds. Most are older than traditional students and have not studied statistics before. They

cannot read quantitative studies that are published in journals of their discipline. Limited background in mathematics is another big challenge. It has been years since they took math courses and have not used the material since. Most of them cannot recognize the same equation if rearranged. Although offering a crash course for one or two days in basic math is a possibility, very few students are likely to benefit from this fast paced arrangement. Besides, the teacher does not have the time to offer this refresher course during the regular class schedule. The diversity in student learning styles, attention styles, and their pace do not permit a single instructional strategy to be uniformally successful for all students.

Relating statistical concepts to various disciplines is another challenge. Without good examples, the statistical concepts are going to stay abstract no matter how eloquently they were presented. Examples taken from child development, educational psychology, and marriage & family counseling are generally understood by all students. However, the instructor can browse through the journals of other disciplines to bring more suitable examples.

Delivering the content in a fixed time is a big challenge in applied courses. Since students in these classes are generally nervous and less excited about the subject matter, the teacher has to present the same material more than once. The repetition occurs in different formats and usually includes different examples. This approach, though very helpful to students, does not leave enough

time to cover all of the topics. As a result, quality control problem is created particularly when the faculty teaching this course is rotated each semester and each professor skips a different topic. When the course is offered in multiple sections, each being taught by a different professor, the discrepancies are even more glaring. The quality issue can be resolved if students' achievement is measured in all sections by the same instrument or by administering a research proficiency examination at the end of the sequence of statistics courses.

It is very difficult to break students' resistance to learn. because they firmly believe that the subject matter is not related to their career goals, at all. Taking a statistics course is the last thing on their mind. As a result, students are not motivated and their only desire is to pass the course to meet degree requirements. In addition, high anxiety caused by fear of failing hinders their learning process. Under the circumstances, it is very difficult for a teacher to make the subject matter stimulating and to provide students rewarding experience.

Teachers in statistics are not trained in pedagogy unless they started their career as public school teachers. The formal training in pedagogy may not be essential if you were (a) teaching statistics to students who have chosen this subject as their field of study, (b) have adequate background in studying the discipline, (c) believe that statistics is a useful area of study, and (d) want to start a career in statistics. Things are just the opposite in applied courses. Imagine a student of forestry who intends to

start his career in forest management. He does not want to be a researchers. His job would be to enforce state and federal laws about pollution and environmental control and to supervise staff. He does not see the need for statistics in carrying out his duties. Take another example of a student who is going to earn doctorate in food management. Her career goal is to manage food services in a reputed hotel chain. She also does not understand how statistics can make her job easier. When students come from different disciplines, have diverse backgrounds, and have no appreciation for statistics and its applications, it is important that the instructor teaching the course be trained in pedagogy to give these students the vision and to resolve the conflicts amicably. On the contrary, these courses are generally assigned to the junior faculty.

Difficulties of Students

Almost all students who take the statistics course are convinced from the very beginning that their mathematical skills are inadequate. They also gather information from fellow students about their experiences in this course. Both of these factors add to their anxiety and start affecting their learning. Those who had adequate preparation in math are also afraid because they took these courses several years ago and have not used the material since then. These students need some time to review the material and are usually less disadvantaged. Others are not only missing computational skills but also the ability of reasoning, abstract

thinking, and problem solving. Students who have these skills do well in the statistics course regardless of their previous math background.

Students enrolled in applied statistics courses are generally nontraditional. They are older working individuals pursuing higher education part-time. They are back to school to improve their education and to step up the career ladder. Most of them are married or are single parents. They work full time, take care of the family, go to school, and then have to set aside time for study. It is a great challenge for them and they are willing to make sacrifices to achieve their goals. However, they are frustrated when in spite of their commitment, effort, and sacrifices, they cannot succeed in this course. They are aware of their shortcomings and are willing to work on them but do not know how. Since most of them hold important positions in real life and have been successful on jobs, they have much to lose and are afraid of failure. They develop negative feelings about their ability to understand concepts and are afraid of asking questions.

The nontraditional students have limited time to avail the benefits offered to a traditional students. Most of them do not live on campus and commute long distances to attend the classes. They cannot access the library, computer labs, the instructor, and fellow students as frequently as we assume they would. Limited contact with classmates deprive them of the opportunity to form study groups or have discussions on various statistical concepts and applications. They also have limited time to reach the

instructor. In addition, the effort that goes into full-time work, meeting job related deadlines, and in handling family emergencies puts so much pressure on them that by the time they come to the class, they are completely exhausted. However, their efforts and sacrifices go to waste when they do not do well in the statistics course. It shatters their resolve that they can excel.

Recommendations

It is obvious that we have a very serious problem at hand. In order to promote statistics in other disciplines we must recruit their students, train them, and make them realize how statistics can improve the quality of their work and product. However, it appears that the system is working the other way around. We do get master and doctoral students from other disciplines in applied statistics courses who would soon assume leadership roles in their area of studies but instead of making them appreciative of statistics, we are turning them off. We make them feel that they are the failures and lack basic skills. These students who feel humiliated and ashamed are not going to be the promoters of statistics. They, in fact, would join forces with those who believe that statistics is not important if you are not a hard core researcher. Of course, this is an undesirable outcome. What we, therefore, need is to create sensitivity among those who teach applied courses to this diverse group of students. A number of recommendations, given below, may seem appropriate.

It is very important that teachers understand their students.

In spite of the difficulties they face in statistics courses, they do not open themselves up before the instructor. Knowing them at the personal level makes them feel that you care for them and you are equally concerned about their success. They start feeling that you are trust worthy and would explain to you their difficulties. They start thinking about you as a friend and not the enemy who is out to get them. All of this can be achieved just by addressing students by name. Additional information like major, address, telephone number for emergencies, current employment if any, computer skills, and previous math and statistics courses taken is also helpful in planning the course and to bring examples in class that would facilitate student learning. Personal information about marital status, number of children, number of credit hours enrolled, and the accessibility of campus services may also be useful in deciding the frequency and length of homework, the grading of home work (letter grade vs pass/fail), the nature of feedback (formative vs summative), office hours to keep, and the arrangements needed to accommodate out of town students. The instructor must, however, explain that the information obtained will be kept confidential and will be used strictly for planning the course. This statement is very important so that students do not view you as invading their privacy. All of this information can be collected during the first class meeting by passing out index cards and asking students to fill in the information. The use of this information in planning and delivering the content would significantly improve student-instructor relationship.

In view of the perceived difficulty of the material, allow students to tape the lecture so that they could replay what they may have missed in the class. For better use of instructor's time, cut down the writing on the board and, instead, bring transparencies of solved examples and lecture keypoints. The savings in instructor's time can be used for further explanation and review of concepts. The copies of these transparencies, if provided to students in advance, would cut down their note taking activity. The time students save from copying the board will be spent in listening to the instructor and the short notes can be taken directly on copies of the transparencies.

The basic mathematical concepts and algebraic rules that an instructor intends to use in the class should be reviewed before teaching the planned content. These review sessions can be conducted out of class by graduate assistants under an instructor's supervision. Using graduate students in the teaching of tutorials make the sessions informal and non threatening to students. As a result, tutorials not only save an instructor's class time but also bring students' diversity in mathematical preparation at a manageable level.

The instructor needs considerable time to carefully prepare homework assignments. The purpose of these assignments should be to motivate the student to do homework, clarify the learned concepts, and promote the use of statistics. The assignments must go beyond the number crunching goal and should provide skill to interpret the results and to assess the impact on relevant theories

and policies. The assignments may require hand computation, use of computer software, or both. If statistical software is involved, make sure that students know how to use the software before assigning the homework or provide a tutorial and lab support to teach the software. The development of such exercises need clarity of purpose, communication skills, and originality. Such custom made exercises serve the purpose much better than the list of problems given at the end of the chapter.

Group experiences bring students together and provide opportunities to share their ideas and explanations in a non-threatening situation. These experiences can be provided in applied courses through group projects. In addition to learning, group projects produce psychological benefits such as the realization that (s)he is not the only one having difficulty in the course. It lowers their anxiety and they start receiving strength from each other. The outcomes of these experiences are higher self esteem, high quality projects, the desire to learn statistics, and the ability to use statistics in their professions.

In order to make group projects interesting and to make them a catalyst of learning, select a number of current issues prevailing in the social and professional domains and ask the groups to select the one they like the most. Allow students to propose their own projects and let them bring data from their work place to analyze the issues. Schedule a meeting with the groups who propose their own project and feel free to trim or expand their project, if needed, to maintain the standards of time, difficulty,

and challenge consistent across groups. In order to promote independent thinking, do not give students the impression that the meeting is to approve or disapprove the project. Instead, suggest changes in the form of recommendations. One or two group projects are reasonable for a 16-week course.

The instructor should regularly observe office hours and must accommodate students who cannot see him/her during posted hours. There should be a reliable service to take messages when the instructor cannot answer the phone. Returning phone calls of students in a timely fashion is not only courteous but a significant factor for out-of-town students. The adult nontraditional students tend to solve their problems at an individual level or with the help of friends. Seeking help from the instructor is the last thing on their list. It is, therefore, important that you return the calls immediately and make every possible effort to help the student. Do not hesitate to extend the deadlines if immediate help cannot be provided. Many times, medical or family emergencies make a student miss test or project deadlines. The instructor should handle such requests in a human and generous way. Suppose a student reports to you that she is not feeling well and needs some extra time to complete the homework. Imagine the relief she would feel if you tell her to take care of her health first and then worry about the test or project. Obviously, a sick student was not going to do very well but an extension in time would give her the opportunity to do her best. Besides, you have not done anything immoral because the student's

grade is still to be determined by the quality of the work turned in.

The academic feedback is an important component to guide students to achieve the objectives set forth in the statistics courses. The feedback should be positive and timely. The delayed response may not have any impact while negative feedback may even discourage students to continue in the program. The instructor should use multiple measures to have a reliable assessment of students' work. In addition, the assessment should be of different kinds. Since tests not only cause anxiety but also take away large amount of instructional time, a combination of tests, quizzes, and homework assignments can be a good alternative. Several 10-15 minute weekly quizzes can be used to test students' understanding of concepts and their applications. In order to minimize random effects and the high anxiety in the beginning of the semester, k best quiz scores out of n quizzes can be used to determine the final grade. In addition to quizzes, two or three tests in a semester can exhaustively assess students' achievement. A review session conducted by a graduate student before the test serves a useful purpose. The homework assignments, if not counted towards final grade, should still be graded to provide feedback.

Since the final grade for the course is generally determined on the basis of a cumulative score, the students generally do not know its distribution until the course is finished. Being unable to predict the final outcome in the course, they stay very tense throughout the semester. It may, therefore, be appropriate to use

separate letter grade for each activity and then sum them together in some fashion to compute the final grade for the course. Separate letter grades keep students informed about their progress in the course.

Students should be required to use computers in completing projects or homework assignments. Out of class tutorials should be available to students so they may learn computer software at their own pace. The skill of using computers should not be used to assess students final grade in the statistics course. However, experience shows that by the end of the semester, almost all students obtain proficiency in using statistical software. The software selected should be easy to learn. Computer skills should be synchronized with the sequence of concepts being taught in the class. It will not do students any good when you are teaching and giving homework about t-test, while computer lab is trying to teach how to run ANOVA on computer. The lab should be supervised to ensure that students receive help in completing their assignments. The lab supervisor should be familiar with students' assignments and the activity should be coordinated with him/her. Eperience has shown that students appointed as Lab Assistants serve student interests better than a full-time employee. Moreover, appointing students to run labs is more cost effective. Lab Assistants free up instructors' time that can be spent planning and preparing material for the class.

The selection of textbook is another important aspect in providing students a positive experience in the statistics course.

Sometimes, instructors select difficult books because the authors are famous and accomplished scholars. These books do not help students learn introductory statistics. They are written at an advanced level. Students need books that supplement the classroom instruction. The book should be written at a level that student could read in advance to get an overview of the next lecture or to complete the notes of the past lecture. Exercises at the end of chapter are very important to give students the practice of using the learned concepts. Select books that support the purpose of your instruction. One should also pay attention to the nature of examples given in the textbook.

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